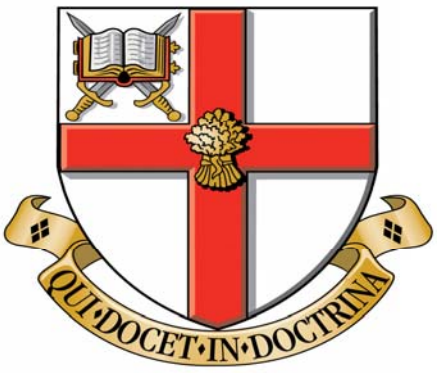

University of Chester

British Handball:
How can Performance Analysis aid the coaching process?

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Word Count – 12,300

Acknowledgements

I would firstly like to thank the England Handball Association and all coaches who took part in the study, their time and effort was crucial to the undertaking of the research and is greatly appreciated. To the National Performance Manager Mick Hegarty, without your willingness and enthusiasm there is no doubt that the study would not have been possible.

I wish to thank my supervisor Dr Paul Worsfold for his valued help and advice throughout the study process. Possibly the biggest expression of gratitude I owe is to Edd Thompson, who was a valued mentor during all stages, supplying me with expert support and guidance from beginning to end. Also I need to pay mention to Sam Moss, who works tirelessly with England Handball and helped me a great deal, thanks Sam.

Special mention is reserved for family and friends especially my brother Owen who continually supplies me with an unending motivation and inspiration to work hard.

Abstract

Despite being the second most popular team sport in Europe (Beech, 2012) handball in Britain it is a developmental sport, trailing behind the majority of Europe in both playing standard and talent pool (England Handball Progress Report, 2011). A crucial factor in the development of youth players is the impact from a coach (Fry; 2010), with performance feedback from a coach essential in aiding athlete improvement (Carling, Williams & Riley, 2005). The purpose of the study was to investigate coach recollection in elite adolescent British handball to explore if the use of Performance Analysis (PA) could aid the coaching process. To further the research into how PA can aid the coaching process, the study also aimed to examine whether game outcome (winning or losing) affects coach recollection. The study gathered results in two sections: firstly 8 coaches completed questionnaires which explored previously defined key indicators of handball performance immediately following three competitive games and secondly data on the same indicators was generated using PA. Following data collection the results were compared and statistically analysed using chi-square goodness of fit tests and tests of independence. Findings of the study reinforce previous literature which has examined coach recollection capabilities, with an overall recollection rate of 33.10% of all indicators. This is similar to the majority of PA studies, which typically discuss the inadequacy of coaches to recall any greater than 40% of pertinent information (e.g. Franks & Miller's, 1986). The study also found that coaches more frequently recalled attacking indicators correctly compared to defensive ones, as well as having more competent recollection ability when a game was lost as opposed to won. These findings not only add to current literature on the subject but also offer insights into potential areas were the coaching process could be aided. This in turn promotes the use of PA, which could potentially aid the development of elite level adolescent British Handball.

Declaration

I confirm that this work is original and has not been previously submitted in support of a degree, qualification, or other course. I have read and understood the University's regulations on plagiarism and I declare that this is my own original work.

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Chapter 1 – Introduction

Handball

The popularity and playing level of team handball across the majority of Europe is much higher than that of the sport in Great Britain. Not only is this proved by the International Handball Federation World ranking list (International Handball Federation, 2013) in which Britain does not even feature, but also by reports on the sport in Britain by the English Handball Association (England Handball Progress Report, 2011). The sport in Britain is classified as developmental, with the aim to promote the game and create stars of the future (England Handball Progress Report, 2011). The England Handball Association (EHA) have discussed how acknowledging early development is essential, in order for the nation to catch-up with the sport in other countries (2011). On the back of the London 2012 Olympic Games, developing youth participation seems to be working with an increase of around 40% of children playing handball at school (England Handball Association, 2012).

When reviewing previous handball literature it is clear that on the main, research into the sport is typically focussed on physiological demands or injury related aspects of the sport (e.g. Povoas et al., 2012). That being said however there are a number of PA based papers which examine handball, with the majority aiming to examine what indicates successful performance in the sport and therefore helping define the key performance indicators of the sport. There is no research into the sport specifically examining British or developmental handball however, which is the area this study aims to address in order to help the development of the sport.

The Coaching Process

An important factor in developing youth players is the impact coaches have on the participants in the sport (Olympiou, 2008; Thomas, Cote & Deakin, 2009; Fry; 2010), with higher standards of coaching having positive effects on the development and performance of athletes. Coaching however is a complex process, described by Franks, Goodman and Miller (1983) as an on-going system of performance; analysis and practise. Coaches will observe and analyse performance before planning training and offering instruction and feedback. A flaw in the process however is that traditional coaching involves subjective observations and conclusions that are based on the coach's perceptions, biases and own previous experiences which are potentially both unreliable and inaccurate (Franks & Miller, 1986). This potential incorrect recollection may negatively affect development as instruction and feedback should be based on information collected by a coach that is objective, unbiased, accurate and as comprehensive as possible (Hughes & Franks, 2008).

Within performance analysis there have been a number of studies examining coach perception and recollection, with the majority suggesting coaches cannot typically recall any greater than 40% of pertinent information of sports performance (Franks & Miller, 1986; Franks & Miller, 1991; Franks, 1993). It has been claimed that these inadequacies are unavoidable and are influenced by several factors such as viewing environment, limitations to human memory, prejudices and emotions (Carling, Williams & Riley, 2005). Although the limitations of human memory may hinder a coach's ability to accurately and objectively recall information, the emergence of PA as a discipline could aid the coaching process. The use of PA can assist coaches' by providing them with objective and accurate information, which consequently enhances coach's interpretation of performance and better informs tactical and technical instruction (Borrie, Jonsson & Magnusson, 2002).

Aims

The aim of this study was to examine coach recollection of performance indicators in handball, immediately following performance in an attempt to better understand recall ability of handball coaches. This may in turn help identify potential areas in handball where objective data could be used to better inform the coaching process. To further the research into how PA can aid the coaching process, the study also attempts to examine whether game outcome (winning or losing) affects coach recollection. This was selected for investigation as work by Franks and Miller (1986) claimed witness accounts in crimes were more inaccurate if there was a high arousal level. This is relevant as winners in sport are associated with having rising testosterone levels, in contrast to losers with falling testosterone (Booth, Shelley, Mazur, Tharp & Kittok, 1989). That being said however it is also argued that although studies have shown negative relationships between memory and level of arousal during incident, other studies have shown a positive relationship (Reisberg, 2003).

To fulfil these aims, the study adopted a methodological approach designed to gather quantitative data in two stages. Primarily data was to be collected from questionnaires (exploring KPIs of handball) completed by coaches (n=8) immediately following competitive handball matches (n=3). The second stage of data collection involved the same matches being analysed with data generated using PA methods. Following this the two sets of data were collated and statistically analysed to examine if any relationship exists between the two. The data sets were analysed overall as well as according to winning and losing matches.

Following consideration of previous research the following hypotheses apply to the proposed study; coaches will not be able to accurately recollect important performance information and therefore coach observations will be consistently different to performance analysis observations. Thus creating the null hypothesis that coach perception data will not differ from that of performance analysis generated data. Also due to previous research suggesting that winning creates a higher arousal level and increased arousal in criminal witnesses causes more inaccurate recollection, winning will decrease recollection in coaches.

Structure of the study

In order to accomplish the aims of the study and answer the research question, the dissertation is presented in a number of chapters. The following chapter provides a review of the existing literature relevant to the study, examining the state and status of British and European handball (e.g. Povoas et al., 2012; Melatakos, Vagenas & Bayios, 2011), the coaching process (Franks, Goodman & Miller, 1983; Carling, Williams & Riley, 2005) and studies into memory recollection (Franks & Miller, 1986; Franks & Miller, 1991; Franks, 1993). This chapter finishes by discussing existing literature on the use of PA as part of the coaching process (e.g. Borrie, Jonsson & Magnusson, 2002) before moving on to focus on the impact winning or losing may have on recollection capabilities (Booth, Shelley, Mazur, Tharp & Kittok, 1989; Reisberg, 2003). Chapter two explains the methodological approach of the study which consisted of questionnaires and data generated by the use of PA. The chapter also explains the participants and their recruitment as well as the statistical analyses undertaken. The results chapter presents the results obtained following the data collection methods which aimed to answer the research question in an attempt to better understand coach recollection. The findings are then concluded, discussing what they add

to the existing field of research into coach recollection as well as the potential to help develop handball and adolescent handball players in Britain.

Chapter 2 - Literature Review

Introduction

The previous chapter aimed to clarify and contextualise this research investigation discussing how PA can aid the coaching process in handball by comparing coach perception and PA data using key performance indicators. This chapter reviews relevant previous literature in an attempt to clarify and to further support its rationale, hypotheses and methodology. To do this the literature review briefly discusses the current state and status of British handball, before examining existing PA specific literature which focuses on the sport of handball as a whole. Previous research discussing coaching processes and recollection, human memory and the use of PA to enhance coaching is then examined. The chapter finishes by detailing how winning and losing has been reported to affect arousal affects, which in turn is discussed as a factor in memory recollection.

British Handball

Handball is the second most popular team sport in Europe (Beech, 2012); however in England it is classed as a developmental sport, which is trailing behind the majority of Europe in terms of both playing standard and talent pool (England Handball Progress Report, 2011). This issue is emphasised by the competitive history of the Great Britain (GB) handball team who have won only seven games since formation in 1969 (losing 58). It is statistics such as these which result in the GB team not featuring in the International Handball Federation World ranking list (International Handball Federation, 2013). Since the beginning of this study GB have unfortunately played their last scheduled competitive international game due to funding cuts. The team may be able to compete in World Championship qualifiers in October 2013 if funded personally however if finance is not

found the team will not compete again until late 2014 (Hope, 2013). At the non-elite level however participation in handball in England has nearly quadrupled over the past three years. According to figures published by England Handball nearly 13,000 people are now participating in the sport as a player at a school or affiliated club, which is almost four times the amount compared to 2010 (England Handball Association, 2012). When looking at the youth level, it has been suggested that there has been an increase by around 40% in school participation alone since the London Olympics 2012 (White, 2013). Youth handball is also benefitting from recent funding from Sport England for grass roots development, which will rise by nearly three times over the next four years. In total, Sport England granted England Handball a total of £1.15 Million, which is nearly triple the amount of Whole Sport Plan revenue funding that the National Governing Body received over the 2009-2013 cycle (England Handball Association, 2012).

The worrying status of the GB handball team demonstrates the need for improved development at the youth level, which at present seems to be flourishing in the wake of the London Olympics as well as improved funding. This therefore enhances the rationale for the study which investigated how PA can aid the handball coaching process using youth level England teams and coaches. The England Handball Association (EHA) has also commented on the issue, acknowledging that early development is essential, in order to catch-up with the sport in other countries who have more established systems and greater talent pools (2011).

Existing Handball Literature

For a sport so popular, existing handball literature is limited compared to similar team sports such as basketball; especially empirically based scientific research with an even

smaller number of PA specific papers. A search using pubmed.gov (August, 2013) entering the keyword ‘handball’ produced 512 results, a figure much lower than ‘basketball’ (2407 results). The majority of studies investigate the physiological demands and/or injury related aspects of the sport with a scarcity of PA based handball research. More relevant to the proposed study is that to date there is no research which specifically examines British Handball, in any sport and exercise science discipline.

Although the majority of handball studies examine physiological aspects of the sport (e.g. Povoas et al., 2012), there are a number of PA-based handball studies (e.g. Gruic Vuleta, Milanovic & Ohnjec, 2005; Melatakos, Vagenas & Bayios, 2011). The work of these aimed to examine indications of successful performance in handball and have been used to determine the KPIs to be used within this study. Work by Melatakos, Vagenas and Bayios (2011) claimed the sport is split into two main phases of play; attack and defence. The main aspect of performance in each of these is shooting, whether it is taking a shot (attack) or defending one (defence). Due to the importance of shooting as an indicator of performance in handball it should be included in any research which aims to study the key aspects of the sport. Investigations into shooting can also be furthered by examining the location of shot taken and outcome of shot. This is mentioned due to research investigations into player position and location of shots in handball which began to appear following the work of Czerwinski (1998). Czerwinski explained that the three areas where shots are taken from are generally the pivot (centre to goal) playing position, backcourt position and the wings. These positions also discussed in more recent work by Gruic, Vuleta, Milanovic and Ohnjec (2005) and Melatakos, Vagenas and Bayios (2011), who classified them in their studies as 6metre shots, 9metre shots and wing shots. Based on

this existing research in handball, any analysis which looks to further analyse shooting should take into account the three areas which have been classified.

The Coaching Process

Research suggests that a crucial factor in the development of youth players is the impact upon players from a coach (Olympiou, 2008; Thomas, Cote & Deakin, 2009; Fry; 2010). This suggests that improving coaching may have positive effects on the development and performance of athletes, which according to Lyle (2002) is the overall goal of a coach in any sport. Generally the coaching process comprises a number of steps (Carling, Williams & Riley, 2005) with Franks, Goodman and Miller (1983) describing it as an on-going system of performance; analysis and practise (see figure 1). Typically the coach will observe performance and then use his/her observations to plan training and provide feedback to the athlete. The delivery of meaningful feedback is extremely important in the process (Shimon, 2011; Starr, 2011) and should be based on information collected by a coach that is objective, unbiased, accurate and as comprehensive as possible (Hughes & Franks, 2008). Successful coaching therefore depends, among other things, on the accuracy of the observation and how well it is analysed; with Bishop (2008) stating that analysis based on accurate observation and recall is a key tool for improving future performance.

Figure.1 – Coaching Process Model (Franks, Goodman & Miller, 1983)

before explaining that although this can be achieved intrinsically it is mostly gained extrinsically through a coach, whose responsibility it is to provide the best possible feedback. In the past there may have been a resistance by some coaches to the use of PA, based on the traditional view that experienced coaches can observe a match (without any aids to the observation process) and report accurately to the players on the critical elements that have determined the outcome (Robertson, 2000). In addition to this many coaches spend a lot of time thinking about how athletes can advance, or attempting to understand the elements to improve performance; relying on what they observe in real-time to support their coaching decisions (Hughes & Franks, 2009). Work by Van Lingen (1997) explained that the basis of good coaching is observation and that shrewd observation and good memory are essential. A flaw in this process however is that traditional coaching involves subjective observations and conclusions based on the coach's perceptions, biases and own previous experiences which are potentially both unreliable and inaccurate (Franks & Miller, 1986). Therefore, it can be said that coaches cannot accurately observe and recall all of the detailed information that is required for a complete understanding or interpretation of performance. This is an issue which has previously been examined in coach recollection studies as well as human memory research, areas which will now be reviewed.

Coach Recollection and Human Memory Studies

Research into human memory and recall behaviour has claimed that remembrance is the drawing together of the past in the present for the purposes of evaluation and making choices. However this will always be subjective as memory is inseparable from moral judgement (Ashmore & Brown, 2010).

More specific to the current study there has been a number of studies which have examined coach perception and recollection, with the majority suggesting coaches cannot typically recall any greater than 40% of pertinent information of sports performance (Franks & Miller, 1986; Franks & Miller, 1991; Franks, 1993). Carling, Williams and Riley claim that a coach's recollection of a soccer match is affected by several factors such as viewing environment, limitations to human memory, prejudices and emotions (2005). It is also claimed that coaches remember only distinctive portions of a competition such as controversial decisions or exceptional performance while non-critical events are most likely forgotten. This is referred to as a form of highlighting and when combined with the emotions and personal bias of the observer it may cause a distorted perception of the game in total (Hughes, 2001; Hughes & Franks, 2008). When looking at emotion however work by Reisberg (2003) claims that emotion may have a positive effect on memory in that it can actually increase memory vividness, accuracy, completeness, and longevity. The author does however explain that many studies also show that emotion impedes accurate memory if the event to be remembered is prominent and summons the main attention of the witness (Reisberg, 2003). In the event of this happening, memory for the critical focus of the event will be enhanced but at the cost of poorer memory for non-critical events (Reisberg, 2003).

Earlier research by Engelhardt (1999) also suggests that human memory is affected by the retelling, and how one rarely tells a story in a neutral fashion. With this in mind it is also possible that by coaches tailoring feedback for their athletes the bias distorts the formation of the memory and therefore, their recollection of sports performance is potentially suspect.

Work by Franks and Miller (1986) considered the coach as an eyewitness of the sport competition and, using methodology gained from applied memory research, showed that international level football coaches could only recollect on average approximately 30 per cent of the key elements that determined successful soccer performance observed during half of a televised game. The study concluded that coaches are not able to accurately observe and recall the detailed information required for a complete understanding of performance. The study compared coaching observations of a sporting event to an eye witness in a criminal event and found that witness accounts were inaccurate if there was a high arousal level and/or number of perpetrators. This information was compared to a group of coaches tested on their ability to recall events that happened in one half of a soccer match. Three experimental groups received varied amount of instruction either prior to or following the game. The results showed that the overall probability of recalling critical events correctly for all coaches was approximately 42%, with no statistically significant differences between experimental groups. Conversely, citing Laird and Waters (2008), O'Donoghue (2010) states that qualified soccer coaches can accurately recall an average of 59 per cent of critical events that occur during a soccer match; higher than Franks & Miller's (1986) reported 42 per cent, but still not a perfect recollection of the game. It was also seen that the events remembered within football with greater accuracy were specific stop start plays e.g. corner kicks, throw-ins (Franks & Miller, 1986), which again shows highlighting of stop-start actions. Hughes and Franks (2004) explained that this is believed to be due to there being discontinuity in the otherwise continuous play for these events which act as a memory jogger. This may be especially relevant to handball, which is being examined in this study, due to the continuous-action nature of the sport which has been promoted over the past decade or so. Trends in the development of the sport, games rules

modifications and changes in performance of game elements, introduced for the sake of play speed and attraction enhancement may be providing handball coaches with fewer instances of this memory jogging and therefore negatively affecting observation and recollection ability. This is a factor touched upon by handball specific research, which claims that the speed and continuity of the sport makes the definition of a small number of basic factors responsible for performance difficult to obtain (Gruic Vuleta, Milanovic & Ohnjec, 2005).

If training and experience have such a profound sensitising effect upon the perceptual abilities of expert observers, it might be possible to modify coaching education methods to enhance observer accuracy and reliability? Franks and Miller (1991) continued the line of research into coach recollection by attempting to do just this and train coaches to observe and recall sports performance more efficiently. The coaches in the study were tested using a video training method which attempted to improve their observational skills. Three groups of soccer coaches were tested prior to and following a training period with the experimental group exposed to a video training programme designed to highlight key elements of soccer team performance and provide a structured framework for future use by coaches when attempting to observe and remember. The general finding of the study was that coaches who used structured predicting (as in the training given) to direct their perceptions were more accurate in their observations than coaches who used non-directed observations. Despite the fact that the training provided improved the coaches' ability to observe and remember, the overall recall of these coaches, even after training was less than 50% accurate. The study also failed to discuss the impact of using such a method has on other aspects of coaching, for example the concentration and therefore time spent following a structured framework to observe performance may affect a coaches ability to

undertake other important tasks such as dealing with substitutions, providing feedback or enforcing tactical changes in game. This therefore promotes the use of performance analysis in creating and supplying objective data to the coach which causes minimal distraction from other important aspects of coaching.

In work by Franks (1993) the author examined perceptions of performance where the action lasted less than two seconds, this time the perceptual abilities of novice and experienced gymnastic coaches were compared. The study provides additional evidence of the failings of human recall ability with the findings suggesting that there were no significant differences between the two groups of coaches. Results did however claim that experienced coaches portrayed an increased amount of false positives (claiming a difference when none existed) than their novice counterparts and were also very confident of their decisions, even if incorrect. This indicates that the level of experience a coach has does not automatically improve perception and recollection accuracy, but may in fact influence them to perceive performance errors even when none exist. In this work it was concluded that; when it comes to feedback provision, a very unreliable source of information is created by processing data though normal human memory (Franks, 1993). Evidence from the studies discussed in this review as well as many others from the field of applied psychology (see Neisser, 1982) suggest that the accuracy of memories of real world events are greatly influenced by many factors which make subjective observations potentially both unreliable and inaccurate. Therefore, if performance observation is limited then the rest of the coaching process could be negatively affected; this consequently highlights the benefits of PA to inform practise and base feedback from (Robertson, 2000).

Opposition Analysis

It is not only self-analysis which requires coach observation during the coaching process. A coach will also have to analyse opposition during games in order to try and discover tactical or technical tendencies in an attempt to identify possible strengths and weaknesses. Analysing opposition has been the subject of a plethora of literature especially in team sports (e.g. Carling, Williams & Reilly, 2005; Hughes, 2008; & McGarry, 2008). Hughes and Bartlett (2008) explained that there is a crucial need for analysts to deliver (to the coach) information which is accurate on opposition players or teams. Murray and Hughes (2001) also discussed the subject claiming it essential to have an understanding of an opponent's strengths and weaknesses, the authors explaining that by modelling an opponent's performance it is possible to predict specific outcomes or patterns and thus alter one's own tactics before the critical incidents have occurred (Murray & Hughes, 2001). Again as with self-analysis however the observation of opposition by a coach will be subjective and subject to the same distortions and biases as discussed previously in this chapter. This therefore creates another area where PA can aid the coaching process by offering coaches objective reliable data on opposition. This will in turn minimise the risk of subjective recollection of an opponent incorrectly informing tactical or technical decisions.

To conclude, it is important that coaches gather as much information as possible in order to base their decisions on objective data before providing feedback or instruction to athletes. With PA assistance this feedback and/or instruction can be provided by the coach quantitatively through statistical analysis or qualitatively through the use of video analysis.

The use of performance analysis to aid the coaching process

The above mentioned studies endorse the use of performance analysis in sports and how it can aid the coaching process by providing objective information. This consequently enhances coach's interpretation of performance (Borrie, Jonsson & Magnusson, 2002). Previous research which has been reviewed here does not however examine any specific areas of performance which need to be objectively presented to a coach to aid the process. The studies have also all examined coach recollection following video viewing which removes certain environmental factors which occur during and can affect live performance (O'Donoghue, 2009). The aim of this study therefore is to examine coach recollection of performance indicators in handball, immediately following performance in an attempt to better understand recall ability of coaches. This may in turn help identify potential areas in handball where objective data could be used to better inform the coaching process. To further the research into how PA can aid the coaching process, the study also aims to examine whether game outcome (winning or losing) affects coach recollection. This has been chosen to be examined as the previously discussed work by Franks and Miller (1986) which compared criminal witness and sports coach recollection, claimed witness accounts were more inaccurate if there was a high arousal level. In the study, arousal levels were not mentioned for coaches however winning and losing has been discussed as affecting arousal levels within sports (Booth, Shelley, Mazur, Tharp & Kittok, 1989). This research suggests that winners are associated with having rising testosterone levels, in contrast to losers with falling testosterone (Booth, Shelley, Mazur, Tharp & Kittok, 1989). This creates an assumption that if arousal levels in crime witness affected memory accuracy it may also affect coaches when winning or losing. That being said however it is also argued that although studies have shown negative relationships between memory and level of arousal

during incident, other studies have shown a positive relationship (Reisberg, 2003). Reisberg's work discussed the link between arousal levels and memory claiming emotion promotes memory for an event's centre and therefore at least part of this promotion depends on bodily arousal (2003).

With the discussed research in mind the following hypotheses apply to the proposed study; Coaches will not be able to accurately recollect important performance information and therefore coach observations will be consistently different to performance analysis observations. Thus creating the null hypothesis that coach perception data will not differ from that of performance analysis generated data. Also due to previous research suggesting that winning creates a higher arousal level and increased arousal in criminal witnesses causes more inaccurate recollection, winning will decrease recollection in coaches.

Chapter 3 - Methodology

The current study compared coach perceptions of performance to objective PA data in elite level handball. In order to carry out the investigation, the study adopted a methodological approach designed to gather quantitative data in two stages. The data collected in the first stage came from the performance analysis of the handball matches. This performance analysis (PA) generated data allowed for objective presentation of the independent variables being examined in the study. These independent variables covered attacking and defending performance of each team being analysed, each variable was listed and given operational definition (appendix 1). The variables examine the court position of shots taken, scored and missed by both teams during a competitive handball match. The specific court positions are wing, six-metre and nine-metre as according to Melatakos et al (2011) these are the three locations where shots are taken from in a game of handball. Data was also gathered for these independent variables in the second stage of data collection through the use of a non-validated coach questionnaire (appendix 2). Following this the two sets of data where collated and statistically analysed to examine if any relationship exists between the two.

Participants

The participants comprised of 8 handball coaches (2 female) from 4 teams (2 coaches for each) all possessing a minimum of a handball level 2 coaching qualification (National Governing Body awarded). All participants coach youth teams (U18) which include male England national team players and coaches are numbered C1 to C8 throughout this study (see table 1). The sample is representative of the population of England national team youth handball coaches (i.e., coaches are from all teams in the country which include England handball youth players). Initial access to the participants was gained through

previous work as a performance analyst to each of the teams by the researcher which can allow greater sensitivity of the research from the participant (Strauss & Corbin, 1998) as well as a greater degree of access to their true opinions because of a previous rapport (Athens, 1984). Although prior knowledge of the participants may be considered a potential source of bias and cause expected responses, access to elite populations are often dependent on the researcher engaging in prior support roles (e.g., Greenleaf, Gould & Dieffenbach, 2001; Gould, Dieffenbach, & Moffett, 2002).

Table 1. Coach list for each team

Team	**Coaches**
Team 1	C2 & C3
Team 2	C1 & C2
Team 3	C5 & C6
Team 4	C7 & C8

Key Performance Indicators

The key performance indicators chosen for the study were shots taken and shots conceded by both teams. This selection allowed the categorisation of the KPIs into two variables according to the main phases of handball play; attack (shots taken) and defence (shots conceded) both dependent on ball possession (Vuleta, 1997). In each category an analysis of the shots was carried out, quantifying location and outcome of shot. Shots were examined as they have widely been recognised as the biggest indicator of performance in handball and are discussed most regularly in research (Vuleta & Simenc, 1989; Czerwinski, 1995; Taborsky, 1996). Examining the location shots were taken from and the outcome of the shots was chosen to be included in the study as the tactical element of knowing where a team or opposition shoots from being an area which could enhance the coaching process

and in turn performance. All KPIs were clearly defined and listed (appendix 1) which was vital as this can aid the identification of good/bad performances of a team or individual by the coach (Hughes & Bartlett, 2008). Clear operational PI definitions have also been discussed as likely facilitating reliability (Bradley et al., 2007; Williams, 2012).

Procedures

Before research began, consent was gained from the England Handball Association (EHA) to carry out the study (appendix 3) and ethical approval granted by the University of Chester's faculty of applied sciences research ethics committee (see appendix 4). Participant information sheets were given to each coach (appendix 5) explaining the primary aims of the research, what participants could expect, how findings would be used and how to contact the researcher. In line with recommendations participants were made aware that the use of pseudonyms would assure anonymity and they could opt out at any time (Denscombe, 2010; Gratton & Jones, 2010). An informed consent form was also to be included (appendix 6); however suggestions by the research ethics committee recommended withdrawing this as the questionnaire was deemed consent when being completed by participants (appendix 2).

Performance Analysis Data Collection

Six competitive league matches (60 minutes) were recorded involving the four teams, with two coaches from each carrying out questionnaires after each game. Therefore three matches for each participant's team were recorded and subsequently analysed according to the chosen key performance indicators (see table 2). The number of games to be analysed was selected due to the number of games left in the Handball season. Three games for each coach created twenty four games for analysis, aiming to increase power and minimise the risk of a type 2 error due to a large sample size (Field, 2009).

Table 2. Game and coach list for the study.

Game	Teams	Coaches Examined
1	Team 1 V Team 2	C3, C4, C1 & C2
2	Team 1 V Team 3	C1, C2, C5 & C6
3	Team 2 V Team 1	C1, C2, C3 & C4
4	Team 2 V Team 4	C3, C4, C7 & C8
5	Team 4 V Team 3	C7, C8, C5 & C6
6	Team 3 V Team 4	C5, C6, C7 & C8

Matches were recorded at the same venue used for England youth handball league games over a period of two weeks. The 6 contests were recorded with a digital camcorder (SANYO XACTI, Japan) from a heightened balcony parallel to the handball court side-line (15 metres distance). Filming was done in line with recommendations from Davidson and Trewartha (2008). Recorded matches were uploaded to a personal computer for analysis using performance analysis software Dartfish ConnectPlus (version 7.0, Switzerland). Analysis was undertaken post-game and due to the relatively moderate occurrence of KPI's being examined matches were viewed at normal speed (50 frames per second). In the rare event that observation was difficult to objectify at this speed the researcher would replay the event and if necessary playback frame by frame, in an attempt to maintain reliability and accuracy in the data collection.

To analyse performance a template was created on Dartfish ConnectPlus 7.0 which allowed the tagging of the selected KPI's with reference to handball court location and outcome of shot (see figure 1).

Figure 1. Dartfish connectPlus 7.0 tagging template.

Reliability

Intra and inter-rater reliability was assessed using the method developed by Cooper, Hughes, O'Donoghue and Nevil (2007), with a 95% required agreement necessary due to the value being the set standard for comparison to coach perception. In line with previous recommendations 95% is the smallest acceptable error and has been discussed as the 'gold standard' (Cooper, Hughes, O'Donoghue & Nevil, 2007) further reinforcing this level being adopted. Intra reliability was carried out due to it being able to test the researcher's reliability in gaining same results over time. Intra-rater reliability however fails to demonstrate any objectivity of the system in that it does not answer whether other operators can obtain similar results using the system (O'Donoghue, 2010). Due to this inter reliability was also tested. Although inter-rater is more difficult to organise as it needs another analyst, the method allows the objectivity of the system to be established, showing how a system is independent of subjectivity (O'Donoghue, 2010). Inter-rater reliability was assessed using the researcher and another operator who is familiar with the system and KPI's having used them previously in performance analysis support work for England Handball. Intra reliability retesting was undertaken using the first quarter of game 1 (due to it having the most occurrences of KPIs – see results chapter). For all KPIs retesting was split into fifteen time cells each 1 minute in duration, the time was chosen in an attempt to

gather a wide range of occurrences of KPIs in each cell. The results for all KPI's indicated 100% exact agreement with a median P-Value of 1, which meets the gold standard discussed (Cooper, Hughes, O'Donoghue & Nevil, 2007). Inter-reliability testing was undertaken using the same set value with the same results (100% exact agreement with a median P-Value of 1). Intra and inter-rater reliability results can be found in appendix 8.

Coach Perception Data Collection

Coach perception was gathered using a percentage based questionnaire immediately post game. The use of questionnaires was selected due to them being a practical and inexpensive method to gain relatively simple, quantitative information from a group (Gratton & Jones, 2010; Neuman, 2011). For the study this was vital as data collection had to be completed immediately following the game. For each question the participant offered a percentage s/he attributed to the KPI according to location on the court, with the three values (in each question) having to add to 100% (appendix 2 & 9).

Statistical Analysis

As the study was novel in its application it was difficult to define the level of agreement/error between coach perception and PA data deemed acceptable. It was initially agreed that, as all KPIs are similar in frequency, all coach responses falling within a level of +/-5% to the PA data will be deemed in agreement and anything out of this will be labelled disagreement. Following a small pilot study however it was decided that +/-10% deviation from the PA data would be examined as well as +/-5% agreement/disagreement in an attempt to compare the two ranges and whether they impact upon results.

For the analysis data provided using PA served as the criteria, coach perception provided the alternative data and the relationship between the two was compared and analysed. In

order to determine whether coach perception data and PA data show a significant relationship or difference, chi squared tests (of independence and goodness of fit) were employed using SPSS. The Chi-square ($\chi 2$) is a test of independence and appropriate for use when data has been collected from two categorical variables (Urdan, 2011); in this study the two categorical variables were agreement (yes/no) with coach perception and performance analysis data informing the outcome. For each independent variable, Chi-squared test was used to assess whether the coaches perceptions are independent of the data generated using PA. Such statistics provide null hypothesis assessments of dichotomous variables; in this study therefore the statistic was used to quantify whether the coaches observations were consistently similar or different to the PA observations. According to the critical values of Chi Squared distribution (Field, 2009) if results were to show a higher value than 3.841 this would indicate that the data collected rejects the null hypothesis (meaning there is a significant difference between data) whereas if results were to create a lower value than 3.841 the null hypothesis would be accepted (there is no significant difference between data). Therefore KPIs which rejected the null hypothesis indicated areas which PA data may aid the coach in, by offering objective data which is not typically recalled during performance. For the study winning and losing games were also analysed separately in an attempt to discover whether there was any difference in the outcome of a game regarding how a coach recollects in-game information. The associated Phi value and Cramers V (effect size) were also reported to provide an indication of the magnitude of the effect between coach and PA observations. When reporting the effect size, classifications were used as small (0.10), medium (0.30) and large (0.50) based on the recommendations of Field (2009).

Chapter 4 - Results

Introduction

This chapter presents the results collected through each stage of the methodology. To begin with an example of a completed coach questionnaire is presented as well as the raw data exported from Dartfish into Microsoft Excel. The Microsoft Excel workbook which was created in order to compare the coach data with the PA data is then shown. From these comparisons, SPSS output tables show the statistical analyses carried out. These analyses were Pearsons chi square tests of independence/goodness of fit, carried out for overall agreement between coach and PA data examining levels of agreement within 5 per cent or 10 per cent. Other aspects which were compared using the afore-mentioned tests included levels of agreement between winning and losing games as well as between attacking and defensive phases of play. For all statistical analyses, key values will be shown and indicated through text and tables based on O'Donoghue's recommendations for presenting data (2012), for a full presentation of SPSS outputs see appendix 7.

PA generated data

The data generated by PA was used to compare coach data against with the occurrence of each KPI according to location shown below. Chart 1 shows the overall instances of each KPI according to location, with the 9m location being the most frequent (217 events, 43%), 6m second most common (162 events, 32%) and the wing position being the most rare location (129 events, 25%). Chart 2 highlights a similar tendency from the distribution of KPI location data for individual games, with the notable difference being the high count of wing shots in game one.

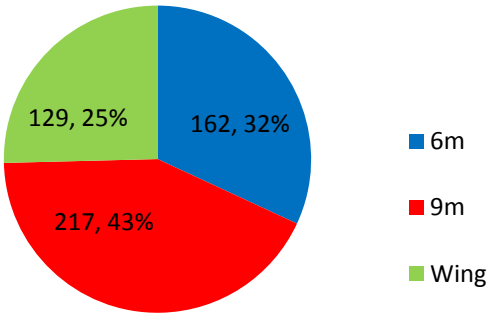

Chart 1. Distribution of overall PA data KPI occurrence according to location.

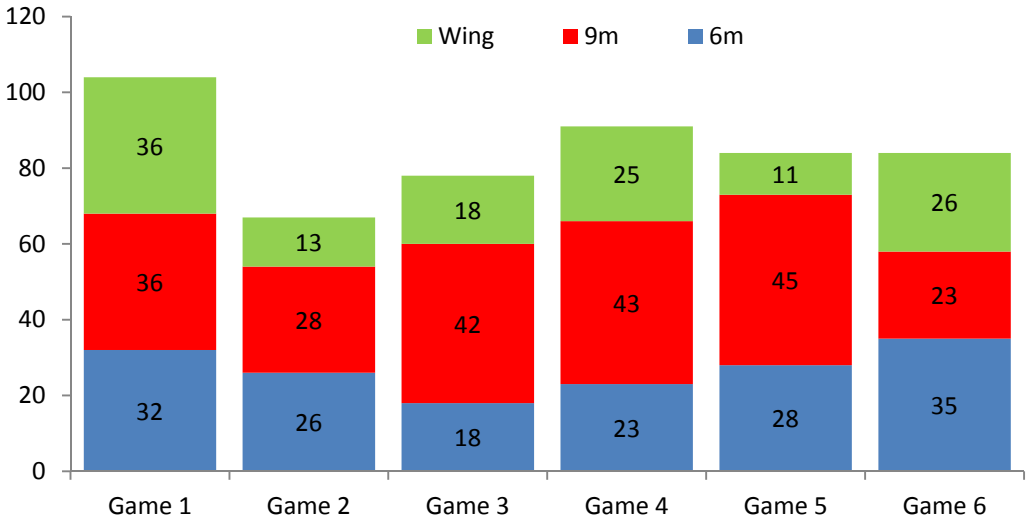

Chart 2. Distribution of each game PA data KPI occurrence according to location.

Overall Results Table

Table 3 shows overall results for a single coach following an individual match, PA data, coach data and the difference between the two values are indicated. The final two columns confirm whether agreement was established within ± 5 and ± 10 per cent between the PA and coach data. The title indicates the coach (1) and game (a) as well as whether the game was won, lost or tied. At the bottom of each table total agreements and percentage for the specific coach/game looked at are presented.

Table 3. Example of a full results table for a set of data from an individual game.

Coach 1a - Tied

Shots Taken	PA data	Coach data	Difference	Agree 5%	Agree 10%
6m	20%	40%	20%	No	No
9m	48%	20%	-28%	No	No
Wings	32%	40%	8%	No	Yes
Shots Scored					
6m	22%	70%	48%	No	No
9m	56%	10%	-46%	No	No
Wings	22%	20%	-2%	Yes	Yes
Shots Missed					
6m	19%	20%	1%	Yes	Yes
9m	44%	40%	-4%	Yes	Yes
Wings	37%	40%	3%	Yes	Yes
Shots Conceded					
6m	41%	90%	49%	No	No
9m	22%	5%	-17%	No	No
Wings	37%	5%	-32%	No	No
Goals Conceded					
6m	40%	90%	50%	No	No
9m	0%	5%	5%	Yes	Yes
Wings	40%	5%	-35%	No	No
Shots Conceded – missed					
6m	37%	80%	43%	No	No
9m	31.5%	10%	-21.5%	No	No
Wings	31.5%	10%	--21.5%	No	No
Agreements				5	6
Percentage (%)				27.78	33.33

From the above example (table 3) it is clear that there are more agreements within 10% than 5% of the PA data, an issue which will be further explored later on in this chapter.

Overall Results

Following compilation of all data the following table was produced which presents the overall results, detailing the number of agreements for each location of KPI within both agreement levels (table 4). Overall agreements and percentages are presented at the foot of the table.

Table 4. Overall agreement results for all coaches compared to PA data

Overall	**Agree 5%**	**Agree 10%**
Shots Taken		
6m	1	2
9m	3	7
Wings	4	14
Shots Scored		
6m	3	5
9m	3	6
Wings	6	11
Shots Missed		
6m	4	13
9m	6	13
Wings	7	12
Shots Conceded		
6m	1	1
9m	1	1
Wings	5	12
Goals Conceded		
6m	2	3
9m	3	6
Wings	7	12
Shots Conceded - missed		
6m	4	8
9m	1	6
Wings	4	11
Agreements	65	143
Percentage (%)	15.05	33.10

The overall data (shown in table 3) is presented in chart 4, creating a visualisation of the distribution of agreements and percentage levels across all indicators. From these results it can be seen that agreements within 10% are more common than within 5% which would be expected.

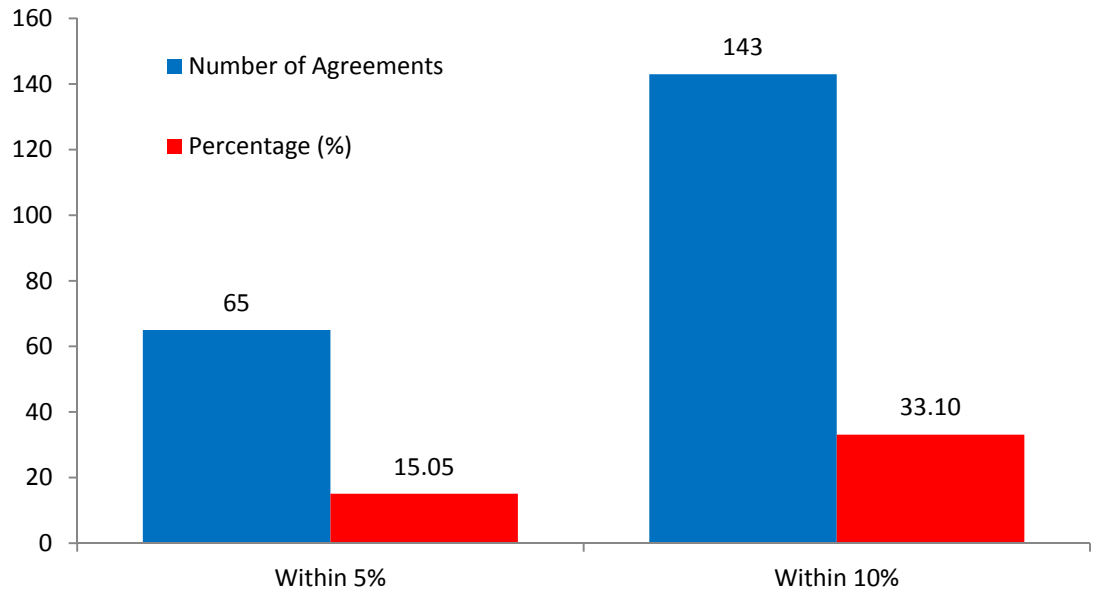

Chart 3. Number of agreements and percentage values between 5% and 10%

Chart 4 is also included as it portray frequency of agreement according to location, with the wing positions having higher agreement and percentage levels than other positions, potentially due to wing position shots being less frequent. Chart 4 highlights higher peaks for wing positions than all other locations, except from the shots missed indicator. Included in the chart is own team and opposition team sections, which indicate own team shooting or opposition team shots. This can also be seen as attacking and defensive indicators and is examined in more detail later on in this chapter. From the chart there is no clear indication of difference between self and opposition (attack and defence) with values to be statistically analysed further on in this chapter.

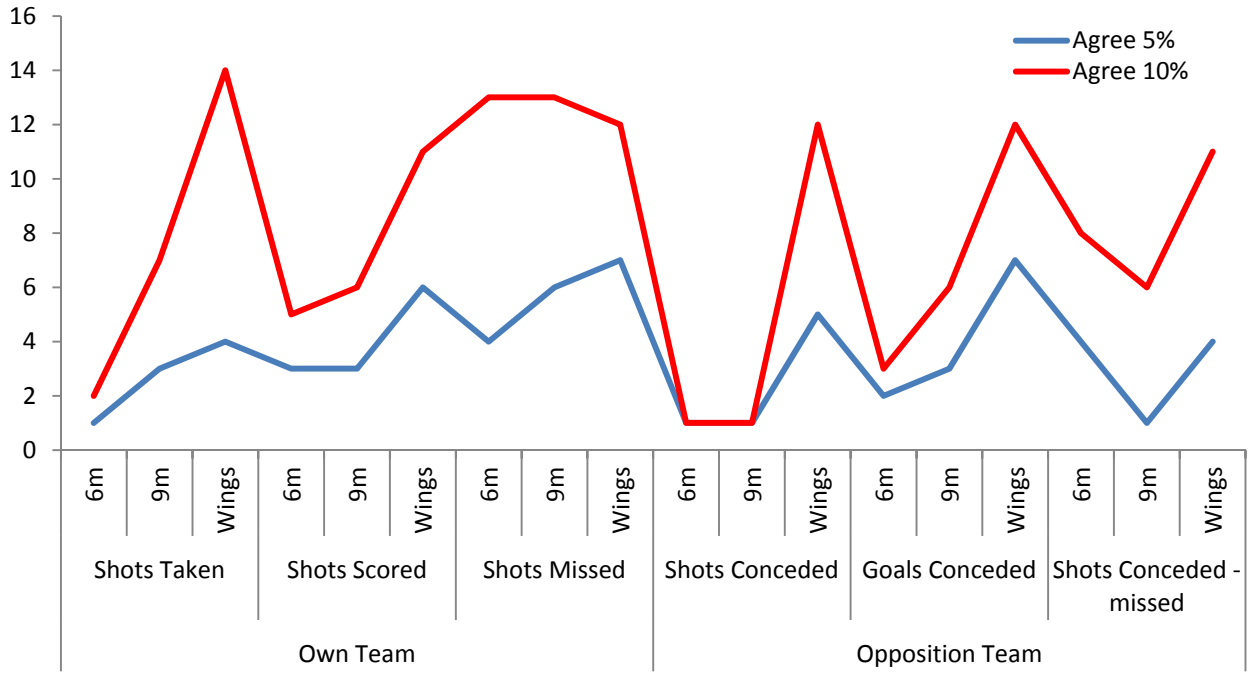

Chart 4. Distribution of overall agreements within both levels across all indicators

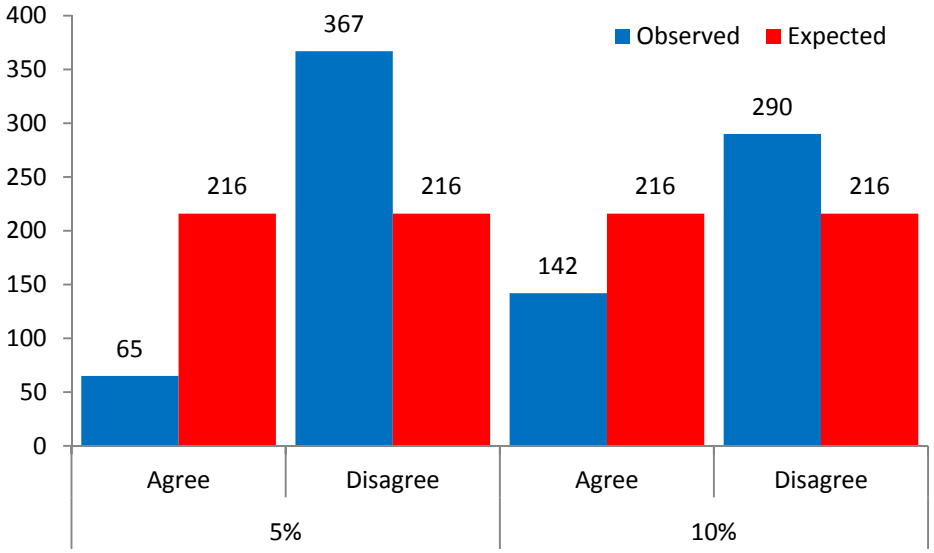

Chart 5. Observed and expected coach agreement with PA generated data (5% and 10%).

Chart 5 shows the observed and expected frequencies for agreement and disagreement, with an expected equal agreement being 216. As is evident this is not the case with an observed agreement in both instances (within 5% and 10% agreement) showing far more disagreements. When carrying out chi square goodness of fit tests for both levels of

agreement (5% and 10%), there was no indicated association or relationship between coach and PA data according to chi square values (5% agreement; $\chi^2 = 211.120, p = .000$; 10% agreement; $\chi^2 = 50.704, p = .000$).

Table 6 shows the results of a chi square test of independence between 5% and 10% levels of agreement. This Chi Square test was performed to determine if agreement within 5% or 10% of PA data was independent of each level. The test indicated a significant difference; $\chi^2 (1) = 37.667, p = .000$. It can be seen that coaches agree more with PA data within 10% than 5% which would be expected and it was this 10% level which would be used to assess the remaining research questions. Cramer's V (.209) and Phi value (-.209) indicate a medium effect size.

Table 6. SPSS output following chi square test of independence between 5% and 10%

		Agreement_Disagreement		Total
		Agree	Disagree	
Five_Ten	5%	65	367	432
	10%	142	290	432
Total		207	657	864

Comparison of agreement between Winning and Losing

In table 7 winning and losing match quantities of agreement are displayed with overall agreement counts and percentages presented at the bottom.

Table 7. Agreement results compared to PA data detailing winning and losing games

	Winning Match		Losing Match	
	Agree 5%	**Agree 10%**	**Agree 5%**	**Agree 10%**
Shots Taken				
6m	0	0	1	2
9m	0	2	2	3
Wings	0	3	4	9
Shots Scored				
6m	1	2	2	3
9m	0	3	1	1
Wings	2	5	3	4
Shots Missed				
6m	2	7	1	4
9m	1	7	4	5
Wings	2	4	3	6
Shots Conceded				
6m	0	0	1	1
9m	0	0	1	1
Wings	4	8	1	4
Goals Conceded				
6m	0	0	2	3
9m	0	0	2	4
Wings	4	5	3	6
Shots Conceded - missed				
6m	1	2	3	6
9m	0	2	1	4
Wings	3	6	1	5
Agreements	20	56	36	71
Percentage (%)	11.11	31.11	20	39.44

From Table 7 it can be seen that more agreements were made following losing matches (36 within 5%, 71 within 10%) compared to winning (20 within 5%, 56 within 10%). To further display this across KPIs Chart 6 highlights the distribution of these agreements with a more clear indication of coach/PA agreement following losses and more specifically defensive indicators (shots and goals conceded) which will be looked at in more detail further on in this chapter.

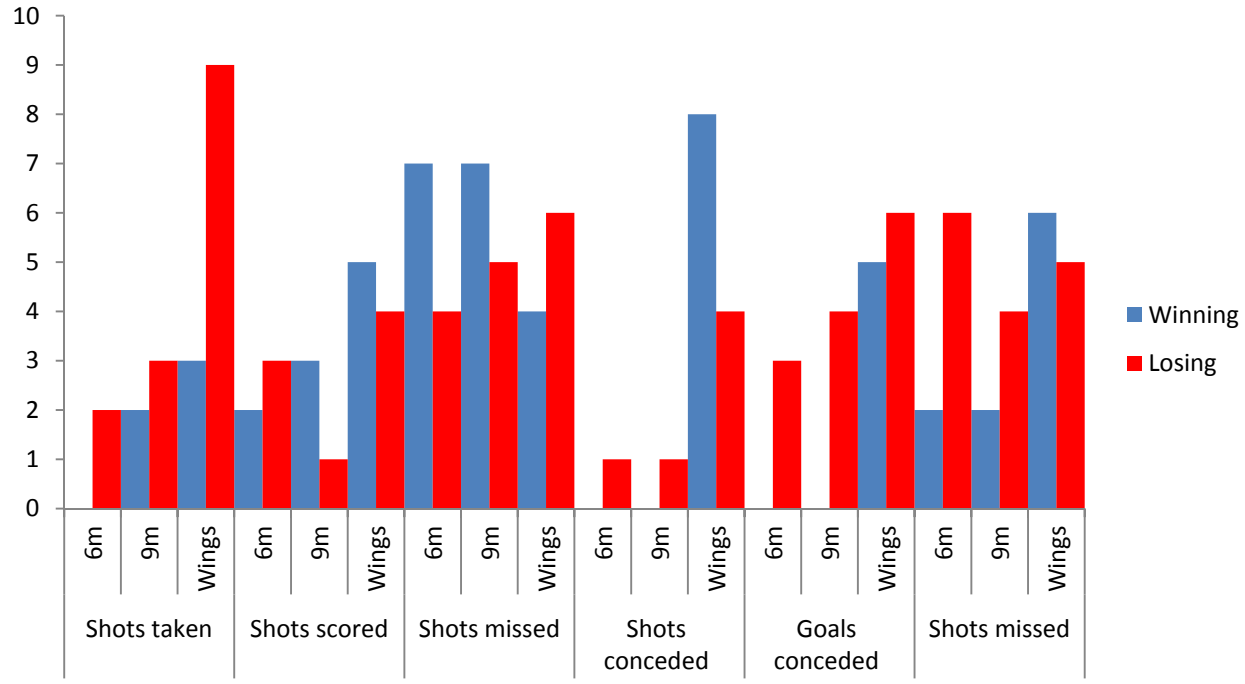

Chart 6. Distribution of agreements between winning and losing.

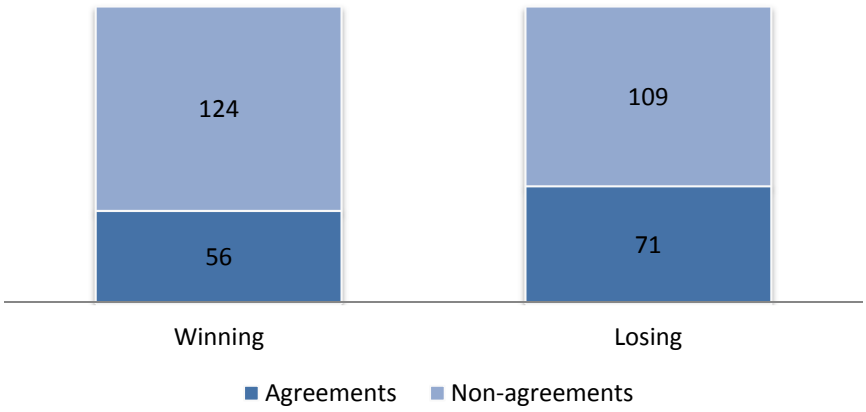

Chart 7. Overall agreements/non-agreements in winning and losing games.

Chart 7 shows the overall agreement/non agreement proportion between winning and losing games, which again highlights more agreement following a loss. Following chi square tests of independence between winning and losing matches a significant difference was inidicated (χ^2 (1) = 3.986, p = 0.046). Cramer's V (.105) and Phi value (-.105) indicate a medium effect size.

Comparison of agreement between Attacking and Defensive phases of play

At touched upon in this chapter already more agreements were made between coach and PA data when discussing attacking indicators (37 within 5%, 83 within 10%) compared to defensive (28 within 5%, 60 within 10%). To further display this across KPIs Chart 8 highlights the distribution of these agreements with a clearer indication of coach/PA agreement when recalling indicators in the attacking phase of play. The data in chart 8 presents the varying agreement levels according to location of KPI, with shots from wing positions again showing a higher level of agreement which is more equal between winning and losing games.

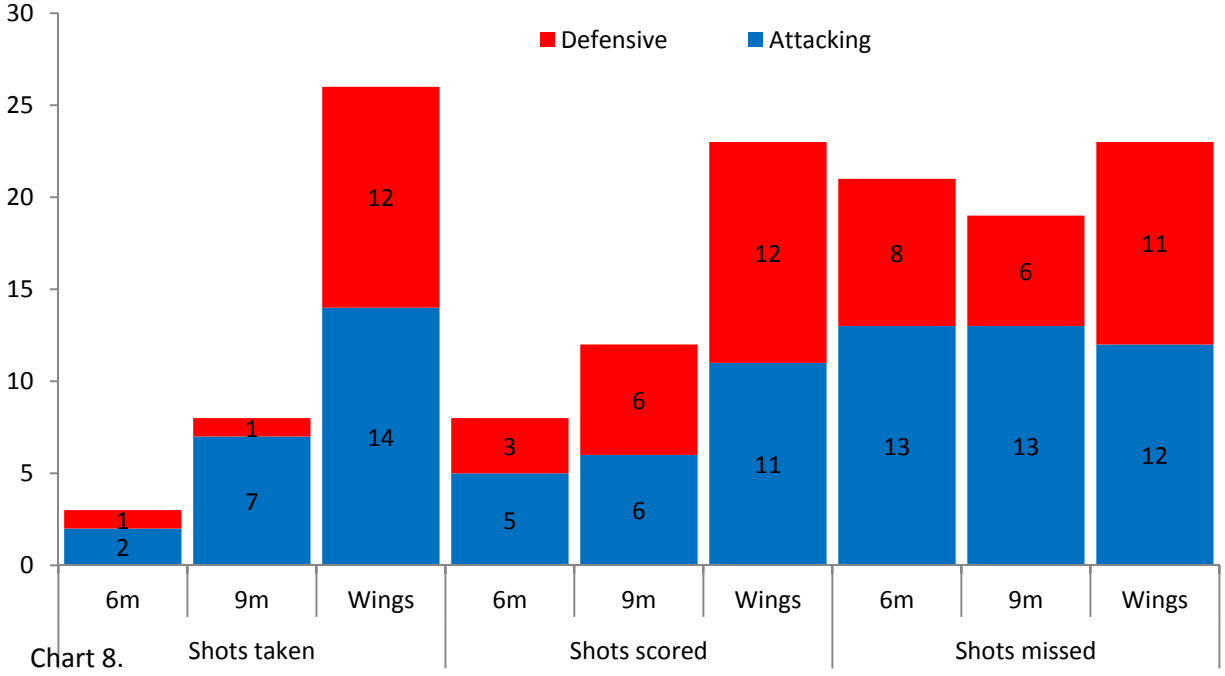

Chart 8.

Distribution of agreements (10%) for KPIs between attacking and defensive phases of play

Chart 9 shows the overall agreement/non agreement proportion between attacking and defensive phases of games, which highlights more overall agreement when discussing attacking indicators than defensive. Following chi square tests of independence between attacking and defensive KPIs a significant difference was indicated (χ^2 (1) = 5.530, p = .019). Cramer's V (.113) and Phi value (.113) indicate a medium effect size.

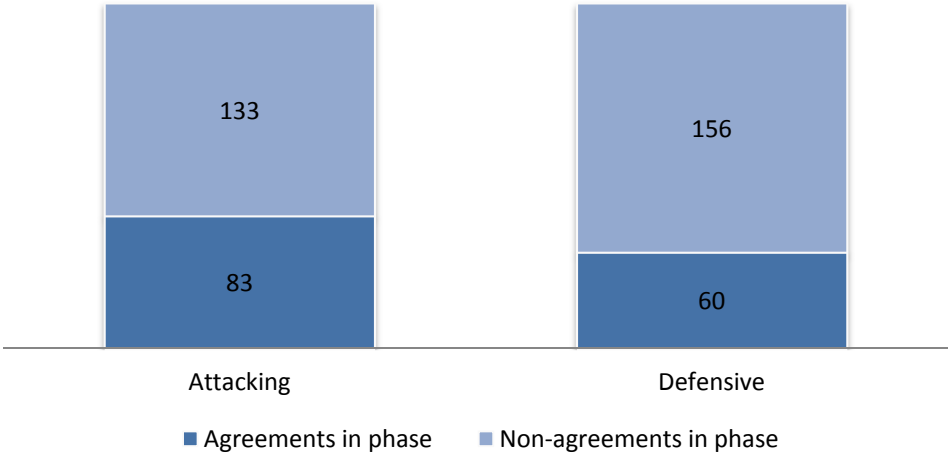

Chart 9. Overall agreements/non-agreements in attacking and defensive phases.

Chapter 5 - Discussion

Introduction

This chapter discusses the issues raised from the results which were presented in the previous chapter. To contextualise the research the study's findings will be clearly stated and then discussed upon with regards to how they support or reject previous literature. The initial section will discuss the distribution of the data generated by PA according to location and how this compares to previous literature before discussing coaches' perception of performance and the relationship it had with the PA data. The chapter continues by examining the difference between using 5% and 10% when classifying coach and PA data as agreement or non-agreement. After this the more specific investigations into the differences between winning and losing as well as attacking and defending in regards to coach agreement with PA data will be discussed.

Performance Analysis data

The findings of the present study indicate that shots from the wing were less common than shots from the 6m or 9m line in elite level youth handball. Chart 1 and 2 in the results section highlight this, with wing shots only accounting for 25% (129 instances) whereas the other two locations are more frequent; 6m accounting for 32% (162 instances) and 9m being the most common with 43% (217 instances). Existing research into elite level senior handball has presented similar findings; however research into elite level adolescent handball is limited to mainly that of Chelly et al., (2011) which examines physiological traits and not shot distribution. It is therefore necessary to compare against senior handball studies. The first work to compare against was that by Ohnjec, Vuleta, Milanovic and Gruic (2008) which examined the Women's World Handball Championship 2008. Regarding the playing positions, the largest number of shots taken was from the backcourt positions

(defined as 9m in this study) with an average of 22.67 shots. Shots taken from the wings' positions where second most frequent (9.80 on average) in Ohjec et al's study (2008) followed by shots taken from the goal area line (defined as 6m in this study) with an average of 6.04 shots. This differed to the study being presented, as although 9m shots were most frequent in both studies, the frequency count of wing and 6m shots were alternate although in Ohjec et al's study (2008) the average amount of wing shots was similar to the frequency of 6m shots. In comparison to studies investigating senior men's handball the frequency of shot distribution according to location is the same across the three locations. Work by Vuleta and Šimenc (1989) analysed descriptively the particular parameters of situational efficiency of the national handball team (of the former Yugoslavia) at the 7th World Junior Handball Championship held in Rijeka in 1987. Most goals were scored from the pivot playing position (6m) and the centre backcourt position (9m). In agreement with the work of the present study the lowest shot effectiveness was registered for the wings (Vuleta & Šimenc, 1989). Gruic, Vuleta and Milanovic (2006) examined the Mens World Handball Championships 2003 with results again ranking frequency in the same order as the present study. The results showed that out of the total average number of shots, 21 shots were taken from the backcourt attackers' positions (9m), 9 shots on average were taken from the 6m line and 8 were taken as side shots from the wingers' playing positions. The last study to compare against was produced more recently by Melatakos, Vagenas and Bayios (2011) and examined whether the variation in shot location had changed due to new rules added to the game. The study analysed three world handball championships (2005, 2007, and 2009). The findings of the research made evident that the amount of shots taken from each location varied at the different tournaments. The order of shot frequency in each location however has remained the same which again was reproduced in the present study into adolescent handball. That being; wing positions

accounting for the least amount of shots followed by 6m shots, with 9m shots being the most common location to shoot from.

It is important to note the difference in frequency as it would be assumed a lower count of occurrence would make it easier for a coach to agree with the actual values of the events in that location. In agreement with this the study found that shots from the wing position were recalled more accurately by coaches than those from the 6m or 9m line. Chart 4 shows agreement by location with KPI occurrence in wing positions offering the highest values of agreement. As suggested this may be due to the occurrence of KPIs in the wing location being the most infrequent and therefore making it easier for coaches to recall. In sport, more frequent KPIs can affect the level of reliability and recollection, as more instances of a specific indicator will in turn increases the potential to miss or recall its occurrence inaccurately. For example in squash a less common indicator such as a boast shot will usually create mostly exact agreements due its low occurrence and it being easy to determine (a boast is a shot played off a wall). Whereas a more common shot such as a drop (a shot played to make an opponent go forward which can also be played off a wall) will have less exact agreements as it is more common and not as clearly defined (Hughes & Robertson, 1998).

Determining Agreement

Prior to discussing the coach agreement results in any more detail it is necessary to consider the percentage difference used in determining agreement with the PA data. For the study, coach results falling within both 5 per cent and 10 per cent of the PA data were examined as agreements and compared (table 4 and chart 3). A chi squared test of independence between 5% and 10% levels of agreement indicated a significant difference. In the results there were more agreements within 10 per cent which was to be expected. In

relation to the presentation and discussion of the results this is important as allowing agreements to be classified when falling within 5% as opposed to 10% will decrease the amount of agreements whereas using 10% may offer too much leeway. For all subsequent analyses both levels were examined, however adopting 10% did not change the results of any statistical analyses and was therefore used in the presentation of results.

Coach agreement with PA data

The main body of literature which the present study aims to add to, generally analyses coach agreement with PA data overall and only immediately following performance (Franks & Miller, 1986; Franks & Miller, 1991; Franks, 1993; Hughes, 2001; Hughes & Franks, 2008). As reviewed in chapter 2 the majority of these studies discuss the inadequacy of coaches to recall any greater than 40% of pertinent information (see previously mentioned research). This percentage varies for differing study however with some recall ability being far higher. For example O'Donoghue (2010) found qualified soccer coaches can accurately recall an average of 59 per cent whereas work by Franks and Miller (1991) which attempted to train coaches to observe and recall sports performance more efficiently, discussed how recollection in 'trained' coaches was improved, but still less than 50% of information was recalled. The findings of the present study, to some extent, reinforce all of the previous literature which discusses the inadequacy of coaches to accurately recall performance. The overall coach recollection (coach agreement with PA Data) of the KPIs chosen for investigation in the study was 33.10% which is lower than that of previous research mentioned, although this was following coaches being questioned immediately following a game instead of viewing a video of performance. This value is created when setting the agreement level of within 10% of the PA data and counting the amount of agreements in relation to the total of agreements possible. If the agreement level of 5% was used the

overall coach recollection value would be less than half at 15.05% (shown in table 4 and chart 3). When carrying out statistical analyses a chi squared goodness of fit test showed no association or relationship between coach and PA data according to chi squared values (5% agreement; χ^2 = 211.120,p = .000; 10% agreement; χ^2 =50.704, p = .000).

This is however only examining and discussing the overall agreement between coach and PA data, with the present study aiming to examine agreement according to the different variables of; phase of play (attacking/defending) and outcome of game (winning/losing).

Winning V Losing

Table 7 shows more coach agreements within both 5% and 10% of PA data in losing matches. These findings suggest that coaches recall information more accurately when games are lost rather than won. Chart 7 presents the overall agreements/non-agreements between winning and losing showing a higher proportion of agreements when games were lost (71 agreements) compared to games won (56 agreements). Chi square tests of independence between winning and losing games also showed a significant difference between coach agreement regarding the game outcome (χ^2 (1) = 3.986, p = 0.046). When reviewing literature on the subject it was suggested that arousal levels may be the cause of this. This was due to winning and losing having been known to have an effect on arousal/hormone levels of athletes within sport (Booth, Shelley, Mazur, Tharp & Kittok, 1989). Which has also been discussed as affecting memory (Franks & Miller, 1986). The present study is however restricted in making extensive comment on this issue as no physiological measurements were taken and therefore no findings can be presented. One potential cause of losing teams coaches recalling information on KPI's more accurately is the frequency of said indicators. Again this issue raises the discussion on how frequently occurring KPIs may be more difficult to recall compared to rarely occurring KPIs. Although

the occurrence of KPIs according to winning and losing is not presented in this study work by Ohnjec, Vuleta, Milanovic and Gruic (2008) have examined the difference between shot occurrences according to match outcome. In the study which examined elite men's handball it was presented that winning teams took on average 3.55 shots more that the defeated teams.. From the backcourt positions the winning teams took 19.76 shots on average whereas the defeated teams directed 25.36 shots on average at the goal. The study raises the important issue of where on the court winning and losing teams take shots from, as has already been discussed in the present study, wing shots were more frequently remembered. That being said however each coach analysed the shooting of both teams and had to to recall the same indicators for winning and losing teams. More research into arousal levels during performance may provide a more extensive answer into why coaches recalled instances more frequently when games were lost rather than won.

From the results the study also found that coaches recall attacking indicators more accurately than defensive indicators. In the study there were more agreements for attacking (37 within 5%, 83 within 10%) compared to defensive (28 within 5%, 60 within 10%). In discussing these findings it can also be suggested that this may be the result of the shot distribution in terms of location or arousal levels during the different phases of play. More research into this would need to be done in these areas in an attempt to investigate this however.

Implications of findings

In discussing the findings it is important to try and determine whether they could form the basis for intervention in the handball coaching process in an attempt to have a positive performance impact. It is quite clear from not only this study but previous studies in the area that due to the limits of human memory coaches cannot accurately recall all the information

following performance. Therefore coaches can be aided by the use of PA through the provision of reliable, accurate and objective data. This can in turn help aid the coaching process when coaches plan tactically and technically for practise and competition.

The findings also indicate the need for the use of PA in analysing opposition. As discussed Hughes and Bartlett (2008) explained the importance of performance analysts to provide a coach with information which is accurate on as many of the likely opposition players or teams, which can be achieved by developing a team/player analysis file library. Murray and Hughes (2001) claimed it essential to have an understanding of an opponent's strengths and weaknesses, explaining that by modelling an opponent's performance it is possible to predict specific outcomes or patterns and therefore alter one's own tactics before the critical incidents have occurred (Murray & Hughes, 2001). There is a high level of research into team (self and opposition) analysis, indicating the potential benefits of providing such support through performance analysis methods. It has been noted (Hughes & Franks, 2004) that in sport, stereotypical ways of playing are often demonstrated by athletes, these being idiosyncratic (personal) models made up of both positive and negative performance traits. The sequences of play are established over time with a greater data set completing a more accurate model of that performer, as a coach this can prove to be beneficial in providing data to compare performance against and offer recommendations for future competition. A performance analyst providing the above will minimise the risk of inaccurate recollection or perception of opponents and decrease the chance of coaches adopting incorrect tactics. PA support should however aim to offer full performance profiling of team and individuals through recognised methods with large data sets (e.g. Hughes, Evans & Wells, 2001; O'Donoghue, 2005; James, Mellalieu & Jones, 2005). By doing this a more accurate understanding of what contributes to good or bad performance in certain individuals can be established (Hughes & Franks, 2004). Analysis of a sport and its team or

player can then be also extended further by examining other performance influencing factors such as environmental factors or the quality and type of opposition (O’Donoghue, 2009).

Chapter 6 – Conclusion

In conclusion the study has found that in adolescent elite level British handball a coach's recollection capability immediately following live performance is limited. This has furthered the research which in the past has just examined coach recall ability following the viewing of videos of performance (Franks & Miller, 1986; Franks & Miller, 1991; Franks, 1993; Hughes, 2001; Hughes & Franks, 2008). Overall coaches did not frequently agree with PA generated data on the same matches. When taking into account all potential agreements coaches only recalled 33%. The study also found that elite level British adolescent male handball has similar shot distribution tendencies to elite level senior men, with wing positions being the most infrequent location of shots and 9m shots being the most common. This may influence the recollection ability of coaches as although further examination needs to be undertaken the study found that coaches recalled wing position shots more frequently than that of any other position. The study again added to the previous research into coach recollection by trying to establish if game outcome affected coach recollection. In the findings of the study it was clear that coaches more accurately recalled information when their team lost the game as opposed to winning. Another finding of the study is that coaches more accurately recalled KPI information when discussing attacking indicators (shots for) as opposed to defensive indicators (shots against).

The above findings promote the use of PA to provide reliable, accurate and objective data, which may help aid the coaching process. As discussed by Ohjec et al., (2008) handball experts and coaches, who can analyse performance during competition, are able to reach an impartial judgement about every player's performance, as well as the performance of the team as a whole. They are also able to do the same for the opposing team and therefore

gain potentially crucial information about the appropriateness of their own tactical and technical instructions either in the actual match or in upcoming fixtures.

The study is not without limitations however with the number of participants offering a maximum of a medium effect size for results; in future a larger group could be used in an attempt to improve this. As touched upon the study does not examine any physiological aspects of participants to see if arousal or hormone levels can be attributed to causing an effect on recollection. In the previous research which was discussed when creating the rationale for the investigation into winning and losing, arousal levels, heart rate or testosterone levels were examined and although the present study found the two game outcomes being significantly different to one another, this cannot be backed up with any physiological data. In the future further analysis would also be required into KPI location and frequency of occurrence, in an attempt to explain the differing results for the wing, 6m and 9m. One last limitation is the analysis of coach recollection over a whole game which removes the ability to test specific time periods of a game or even between halves.

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Appendices

Appendix 1: Key Performance Indicator list and definitions.

Appendix 2: Coach Questionnaire

Appendix 3: EHA letter of approval

Appendix 4: Ethical approval

Appendix 5: Participant Information Sheet

Appendix 6: Informed Consent

Appendix 7: USB Memory stick

Appendix 8: Reliability Results

Appendix 9 – Example of a competed coach questionnaire

Appendix 1: Key Performance Indicators and location definition

Performance Indicator	**Definition**
Shot Taken	Any shot taken at goal which has the intention of or ability to score a goal.
Shot Scored	Any shot taken which crosses the goal line to score a goal.
Shot Missed	Any shot taken which either misses the goal or is blocked by any other player.

Location	**Definition**
6m	Six-meter: shots from the pivot position, which is from a zone outside the 45° angle from the left and right
9m	Nine-meter: shots from outside the backcourt marking.
Wing	Wing: throws from within an angle of 45° left and right

All indicators adapted from the work of Melatakos, Vagenas,and Bayios (2011) and exclude penalty shots.

Appendix 2: Coach Questionnaire

Coach Questionnaire

Please indicate a percentage for each location according to the Performance Indicator.

For each question the three values must add up to 100%.

1

Shots taken	Percentage (%)
6m	
9m	
Wings	

2

Shots scored	Percentage (%)
6m	
9m	
Wings	

3

Shots missed/saved	Percentage (%)
6m	
9m	
Wings	

4

Shots conceded	Percentage (%)
6m	
9m	
Wings	

5

Goals conceded	Percentage (%)
6m	
9m	
Wings	

6

Shots conceded - missed/saved	Percentage (%)
6m	
9m	
Wings	

Appendix 3: EHA letter of approval

ENGLAND HANDBALL ASSOCIATION
"Delivering the Olympic Legacy"
Unit G3, Barton Hall Estate, Hardy Street, Eccles, Manchester, M30 7NB
0161-707-8983
handball@englandhandball.com
www.englandhandball.com

3rd June 2013

Dear Sir/ Madam, - Chris Connelly- Ethics Letter

With regards to invaluable contribution which Chris Connelly is making towards the improvement in Elite Youth Handball within the England Handball Talent Pathway; on behalf of the EHA, I would like to confirm EHA permission to film athletes in competition and training, access and questionnaire coaches for research purposes and to use necessary facilities needed for purposes of research.

Chris is currently a member of the England Handball Talent Pathway Sports Science Staff which is a partnership between EHA and Chester University Department of Sports and Exercise Sciences (please refer to Craig Twist for more information). He is required to work with the players on a regular basis, at all times under the supervision of fully qualified and CRB'd staff and has no access to players on his own.

He is also required to attend various training camps and competitions both in the UK and abroad where the EHA has access to a number of different facilities, including:

- Birchwood Sports Facility (Warrington)
- University of Chester, Warrington Campus, Padgate gym
- Halliwell Jones Stadium
- Arhus Handball Academy (Denmark)
- Ochtrup Training Base (Germany)

I am happy to endorse the use of these facilities both in the UK and during competitions taking place abroad for the purposes of research. If you have any other questions or require further information then please do not hesitate to contact me.

Yours sincerely,

Mick Hegarty

EHA National Performance Manager

Let the dream become the reality

Appendix 4: University of Chester Ethical Approval

Attached

Appendix 5: Participant Information Sheet

Elite Level British Handball: How Can Performance Analysis aid the coaching process?

You are being invited to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

What is the purpose of the study?

Previous studies have suggested that coaches cannot typically recall any greater than 40% of pertinent information of sports performance (Franks & Miller, 1986; Franks & Miller, 1991; Franks, 1993). Information which is recalled tends to include controversial decisions or exceptional performance while non-critical events are most likely forgotten. This form of highlighting when combined with emotions and personal bias of the observer may cause a distorted perception of the game in total (Hughes, 2001; Hughes & Franks, 2008).

Previous studies have endorsed the use of PA in sports as it can provide objective information which will enhance coach's interpretation of performance. They do not however offer any real insight into areas of performance which need to be objectively presented to a coach to aid the process. The studies have also all examined coach recollection following video viewing which removes certain environmental factors which occur during and can affect live performance.

The aim of this study therefore is to examine coach recollection immediately following performance in an attempt to better understand recall ability of coaches, which may in turn help identify potential areas in handball where objective data could be used to better inform the coaching process. To further the research into how PA can aid the coaching process, the study also aims to examine whether game outcome (winning or losing) affects coach recollection. This has been chosen as winning and losing has been discussed as affecting arousal levels within sports, which may affect recollection capability (Booth, Shelley, Mazur, Tharp & Kittok, 1989).

Why have I been chosen?

You have been chosen as you are a qualified handball coach who coaches elite level British handball players.

Do I have to take part?

It is up to you to decide whether or not to take part. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of care you receive in any way.

What will happen to me if I take part?

If you decide to take part you will be required to complete a short questionnaire discussing your teams performance immediately following a game. The questionnaire should take no longer than 5 minutes to complete and you will only be required to do this following a maximum of five games. Your responses will then be compared to performance analysis data in an attempt to discover any

potential areas in your teams performance where objective performance data would be useful to you as a coach.

What are the possible disadvantages and risks of taking part?
Possible risks by taking part in the study are minimal as all information will be kept strictly confidential and anonymous at all times. Any information you give to the study will not be associated with your name and pseudonyms will be used. One disadvantage may be postponing your game debrief to your players by a short amount of time will you complete the questionnaire.

What are the possible benefits of taking part?
There are a number of benefits of you taking part in the study, the first being that the data provided could aid you in the coaching process by highlighting any areas of weakness or strength in your team which you may not be aware of, in turn aiding the coaching process. The study also aims to help develop the sport of handball by assessing areas in performance analysis could better serve handball coaches. By agreeing to participate you will also be helping progress academic research into handball which at the present time is limited.

What if something goes wrong?
If you wish to complain or have any concerns about any aspect of the way you have been approached or treated during the course of this study, please contact Professor Sarah Andrew, Dean of the Faculty of Applied and Health Sciences, University of Chester, Parkgate Road, Chester, CH1 4BJ, 01244 513055.

If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone's negligence (but not otherwise), then you may have grounds for legal action, but you may have to pay for this.

Will my taking part in the study be kept confidential?
All information which is collected about you during the course of the research will be kept strictly confidential so that only the researcher carrying out the research will have access to such information. All data will be coded to ensure anonymity

What will happen to the results of the research study?
The results of this project might be published but any data included will in no way be linked to any specific participant.
You are most welcome to request a copy of the results of the project should you wish.
The data collected will be securely stored in such a way that only those mentioned above will be able to gain access to it.

Who is organising and funding the research?
The Department of Sport and Exercise Sciences at the University of Chester will be involved in organising and carrying out the study.

Who may I contact for further information?
If you have any questions about the project, either now or in the future, please feel free to contact;

Christopher Connelly – University of Chester
Email: @chester.ac.uk

Thank you for your interest in this research.

Appendix 6: Informed Consent

INFORMED CONSENT FORM

Elite Level British Handball: Can Performance Analysis aid the coaching process?

Christopher Connelly

Please tick the box if you agree with the statement:

I confirm that I have read and understood the participant information sheet for the above-named study, and have had the opportunity to ask the lead researcher any questions. ☐

I understand that my participation is voluntary, and that I am free to withdraw from participating in the study at any time, without giving any reason and without my rights being affected. ☐

I agree to take part in the above study. ☐

Name of Participant	Date	Signature
Name of Person taking consent (if different from researcher)	Date	Signature
Name of Researcher	Date	Signature

(*1 for participant; 1 for researcher*)

Appendix 7: USB Memory stick

Attached

Appendix 8: Reliability Results

Intra Testing

Cell number	Test score	Retest score	Difference score
1	4	4	0
2	5	5	0
3	4	4	0
4	6	6	0
5	3	3	0
6	4	4	0
7	6	6	0
8	2	2	0
9	1	1	0
10	5	5	0
11	2	2	0
12	1	1	0
13	1	1	0
14	4	4	0
15	3	3	0
	Positive values		0
	Negative values		0
	Zero difference		15
	Median sign test *P* - value		1
	Percentiles	2.50%	0
		97.50%	0

	Time cell	Perfect agreement?	+/-1 agreement?
	1	Y	Y
	2	Y	Y
	3	Y	Y
	4	Y	Y
	5	Y	Y
	6	Y	Y
	7	Y	Y
	8	Y	Y
	9	Y	Y
	10	Y	Y
	11	Y	Y
	12	Y	Y
	13	Y	Y
	14	Y	Y
	15	Y	Y
	Y	15	15
	N	0	0
Proportion of exact agreement (%)		1	1
Proportion of exact agreement		100	100
q		0	0
SEpa		0	0
Positive 95 decimal CI		1	1
Negative 95 decimal CI		1	1
95% CI (upper)		100	100
95% CI (lower)		100	100

Inter Testing

Cell number	Test score O1	Test O2	Difference score
1	4	4	0
2	5	5	0
3	4	4	0
4	6	6	0
5	3	3	0
6	4	4	0
7	6	6	0
8	2	2	0
9	1	1	0
10	5	5	0
11	2	2	0
12	1	1	0
13	1	1	0
14	4	4	0
15	3	3	0
	Positive values		0
	Negative values		0
	Zero difference		15
	Median sign test *P* - value		1
	Percentiles	2.50%	0
		97.50%	0

	Time cell	Perfect agreement?	+/-1 agreement?
	1	Y	Y
	2	Y	Y
	3	Y	Y
	4	Y	Y
	5	Y	Y
	6	Y	Y
	7	Y	Y
	8	Y	Y
	9	Y	Y
	10	Y	Y
	11	Y	Y
	12	Y	Y
	13	Y	Y
	14	Y	Y
	15	Y	Y
	Y	15	15
	N	0	0
Proportion of exact agreement (%)		1	1
Proportion of exact agreement		100	100
q		0	0
SEpa		0	0
Positive 95 decimal CI		1	1
Negative 95 decimal CI		1	1
95% CI (upper)		100	100
95% CI (lower)		100	100

Appendix 9 – Example of a competed coach questionnaire

Cla
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Coach Questionnaire

University of Chester

ENGLAND HANDBALL

Please indicate a percentage for each location according to the Performance Indicator.

For each question the three values must add up to 100%.

1

Shots taken	Percentage (%)
6m	40%
9m	20
Wings	40%

2

Shots scored	Percentage (%)
6m	70
9m	10
Wings	20

3

Shots missed/saved	Percentage (%)
6m	20
9m	40
Wings	40

4

Shots conceded	Percentage (%)
6m	90
9m	5
Wings	5

5

Goals conceded	Percentage (%)
6m	90
9m	5
Wings	5

6

Shots conceded - missed/saved	Percentage (%)
6m	80
9m	10
Wings	10

7 . Most Effective Player (Number) ..... 1 .....

8. Position of Player ..... G.K .....

9. Main Strength during game ..... Saves .....